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## NEW EXPERIMENTS ON FRICTION, MADE AT METZ, 1831, 1832, AND 1833, BY ARTHUR MORIN, CAPT. OF ARTILLERY.

[Concluded from page 69.]

The third memoir of M. Morin, embraces several distinct objects of inquiry, viz., the friction of building materials—the transmission of motion by a blow—the penetration of certain media by projectiles—the same while the body struck is in motion, in a direction perpendicular to that of the blow—and the friction of surfaces as modified by sudden pressure or by a blow. The whole memoir is concluded by a notice of the application of the peculiar apparatus employed, to various other physical enquiries.

It is that portion only which treats of the first named subject that we propose condensing into the present article. The latter subjects although highly interesting referring rather to military engineering or being of less general value. The friction of building materials of different kinds, was as might have been anticipated from the previous experiments, precisely in accordance with the three general laws of this species of resistance, viz.:

In proportion to the pressure.

Independent of the velocity.

Independent of the extent of surface.

A few words may be necessary in explanation of the nature of the material experimented upon. The *soft limestone*, or limestone of Jaumont is an oolite being of medium hardness, of a yellow color and having a very even texture.

The *hard limestone* or limestone of Brouck is the muschel kalk of geologists. It is the hardest limestone of the department—takes a fine polish—is of a light green color and exceeds the last in specific gravity by a little more than one third.

The bricks used were of the common kind, well baked, red without any signs of vitrification and very homogenous.

It might be thought that the limestones mentioned, being without representatives in this country, are not proper subjects of experiments, the results of which are to be used in this country, but it will be seen that their nature is such that they may fairly be taken to represent the extremes between which all our serviceable building stone may be found. As in the previous experiments it was found that the powder arising from abrasion of the surfaces did not interfere with the fixed laws of friction. The hard limestone seems to have abraded but little, and when two pieces were rubbed together, a fine polish resulted.

The tables are constructed in all respects as before.

*Friction of surfaces after having been in contact for some time.*

New experiments are given in the table, upon cast iron, as being the most frequently used in machinery. The set is otherwise parallel with the one on friction during motion. The author has also added an experiment on the friction of limestone with mortar interposed—the mortar being composed of one part lime and three sifted river sand. The duration of contact varied in each series from 5 seconds to fifteen minutes, the results in no case varying to any extent from the mean of the whole.

## TABLE III.

*Friction of Surfaces in Motion. Building Materials.*

| Nature of the surfaces in contact. | Condition of surface as to unguent, etc. | Arrangement of fibres. | Proportion of friction to pressure. |
|---|---|---|---|
| Soft limestone on soft limestone. | none | | 0.64 |
| Hard limestone on soft limestone. | " | | 0.67 |
| Common brick on do. | " | | 0.65 |
| Oak on do. | " | vertical. | 0.38 |
| Wrought Iron on do. | " | | 0.69 |
| Hard limestone on hard limestone. | " | | 0.38 |
| Soft limestone on do. | " | | 0.65 |
| Common brick on do. | " | | 0.60 |
| Oak on do. | " | vertical. | 0.38 |
| Wrought iron on do. | " | | 0.24 |
| Wrought iron on do. | water. | | 0.30 |

## TABLE IV.

*Friction of Surfaces which have been for some time in contact. Building Materials.*

| Nature of the surfaces in contact. | Condition of surfaces as to unguent, etc. | Arrangement of fibres. | Proportion of friction to pressure. |
|---|---|---|---|
| Cast iron on cast iron. | lard. | | 0.10 |
| Oak on oak. | none. | vertical. | 0.43 |
| Soft limestone on soft limestone. | " | | 0.74 |
| Hard limestone on do. | " | | 0.75 |
| Brick on do. | " | | 0.67 |
| Oak on do. | " | vertical. | 0.63 |
| Wrought iron on do. | " | | 0.49 |
| Hard limestone on hard limestone. | " | | 0.70 |
| Soft limestone on do. | " | | 0.75 |
| Brick on do. | " | | 0.67 |
| Wrought iron on do. | " | | 0.42 |
| Oak on do. | " | vertical. | 0.64 |
| Soft limestone on soft limestone. | mortar. | | 0 74 |

For the American Railroad Journal and Mechanics' Magazine.]

## CONFUSION WORSE CONFOUNDED.

There are few subjects of general interest on which the public mind is less enlightened, than on that of "*railway expenses*," and such attempts as have been made to render it clear, have had for the most part the contrary tendency, of only mystifying it the more. So much of extraneous expense, *that for which the railway is in no way accountable*, has attached itself to many of our principal lines, and gone in partial or entire destruction of their profits, that this bewilderment is not so surprising, particularly when professional men lend their aid to entangle it the more, in essays similar to that found in the September number of the Journal of the Franklin Institute, by Charles Ellet, Jr. Civil Engineer.

In classifying these expenses on railways, under distinct heads, he accompanies them with the following vague qualification.

"This formula takes proper account of the difference of grades, but is not applicable to very short roads—to roads doing a very inadequate business—by which I mean a less business than can be accommodated by one engine—nor to the first four years operations, while the road, cars, and locomotives are yet all new."

We propose to show, that if this formula is not applicable to *short* roads, and roads doing a *small* business, still less is it so, to *long* roads doing a *large* business. This can be done by taking the Philadelphia and Pottsville Railway, say 100 miles long, and which will shortly be in a position to do a business of at least 500,000 tons of coal per annum, and comparing it in order with his classification of expenses.

I. *Repairs of road. That repairs of a road consist of two distinct divisions; the first of which is nearly independent of the amount of the trade, and may be estimated on the average, at about* $500 *per mile. The second division is dependent on the amount of the tonnage, and represents the injury done by the passage of one ton of freight. I estimate this wear and tear at .35 of a cent per ton per mile.*

The wear and tear independent of trade, would of course be from the beginning, while that dependent on trade, would be entitled to the allowance for new—but let us charge the whole from the start, thus:

| | | |
|---|---|---|
| 100 miles, wear independent of traffic, $500 per mile, | 50,000 | |
| 500,000 tons of traffic, wear thereby, $\frac{35}{100}$ of a cent per ton, per mile, | 175,000 | $225,000 |

Now the entire cost of superstructure to which this wear is applicable, at present prices of materials, may for 100 miles be given as follows:

| | | |
|---|---|---|
| Iron rail, 8,500 tons for 100 miles, at $35 per ton, landed free of duty, is | 297,500 | |
| Spikes and chairs for 100 miles, at $450 per mile, | 45,500 | |
| Wooden oak sleepers, 170,000 for 100 miles, at 30 cents each, | 51,000 | |
| Labor of relaying track at $400 per mile, | 40,000 | 434,000 |

Allowing therefore the iron rail to be rendered useless, (not destroyed) in two years, and that an entire new superstructure would be required in that time, the old materials would certainly go in reduction of the loss, and which may be estimated to produce at least, say

| | | |
|---|---|---|
| 2200 tons of iron rail left, being fair bar iron, and worth as such at least $60 per ton at present duty of $27 per ton; but say it sells only for good pig, at $30 per ton, is | 24,600 | |
| Spikes and chairs, as old iron, at 50 per cent. of cost, | 22,700 | |
| Wooden oak sleepers, as cord wood, worth at least | 15,300 | 284,000 |
| Loss in two years, | | $150,000 |

Thus at this annihilating and improbable rate of wear even, the loss could only be $75,000 per annum, while by Mr. Ellet's formula, it is made triple that sum, or $225,000 per annum.*

What then is the probable truth in this respect?

*For righting and adjusting track.*

| | |
|---|---|
| This must be comprised in Mr. Ellet's item of $500 repairs, independent of trade—is however a mere matter of labor and is covered by almost $350 per mile, and serves as well for ten as for one daily train over the track; for 100 miles is | 35,000 |

*For slight repairs.*

| | |
|---|---|
| Such as spikes, broken chairs, an occasional defective rail, etc. at say $150 per mile, per annum, | 15,000 |
| | $50,000 |

* It may be remarked that if the iron rail brought the ordinary price of bar iron, and it is so credited when defective rails are used in the workshops of railways, that a superstructure thus sold at the end of two years would realize a handsome profit!

being $500 per mile, per annum, for the first 6 to 7 years, after which, allowing an average duration of 25 years to the iron rail and stone work, 7 years to the cross ties and 12 years to the wooden portion of the bridges, $250 additional, or $750 per mile, per annum, average, would maintain and entirely renew the track *doing any amount of business.*. This is of course applicable to roads of *good materials well put together*—and these expenses will be always in an ascending and descending scale, never exceeding an average of $750 per mile, per annum, which would at ordinary prices refurnish all the materials and pay the labor of always keeping up the entire track to the *standard of new.*

II. *Expense of cars. The expense of repairing and renewing the burthen cars is proportional to the distance which they run, or to the tonnage of the line; and may be estimated at .45 of a cent per ton, per mile.*

A car, carrying 3 1-2 tons of coal, (the capacity of those on the Pottsville road) would therefore at .45 of a cent per ton per mile, cost $1 57 per trip, and performing in the year 125 trips, woulld in all expend in repairs per annum, $197 per car.

| | |
|---|---|
| The entire cost of a coal car is about $250 consisting of wood or perishable material, say | 80 |
| Iron or comparatively imperishable materials, in axles, wheels, bolts, etc. | 170 |
| | $250 |
| Deduct for old iron, | 80 |
| | $170 |

being the amount left to be ultimately provided in renewal of the car, while according to the formula of Mr. Ellet, it would more than eat itself up annually, by expending $197 in that time.

What then is the probable truth in this respect? According to the experience on the roads in England and this country, the wear and tear on passenger and burthen trains is found to be nearly equalized—the lower speed of the latter nearly compensating for their rougher usage, and about ten per cent. per annum on their cost is admitted to be a competent average to replace them. But as a coal car may be supposed to be subject to more than ordinary hard usage, a charge of 15 per cent. per annum is allowed in its case, and according to which it would be consumed in 6 to 7 years, instead of being more than used up in *one year*, according to Mr. Ellet.

III. *Expense of agents, conductors, force at depots, breakmen, and contingencies of all sorts, is likewise nearly proportional to the business of the road, and cannot be assumed at less than six mills per ton, per mile.*

On a business of 500,000 tons, the expense annually at 6 mills per ton, would be only $30,000.

What then is the probable truth in this respect? In this item, the allowance is as much under, nearly, as the others are over the bounds of reasonable probability, and may be stated as follows.

| | |
|---|---|
| Agents, such as president, clerks at depots, book keepers, etc. $150 per mile, per annum, | 15,000 |
| Conductors and breakmen on trains, say 100 men at $300 per annum, | 30,000 |
| Force at depots, say 30 men, at $300 per annum, | 9,000 |
| Contingencies of all sorts, such as pensions from accidents, fire from locomotives, etc., | 12,000 |
| | $66,000 |

The first and last of these items appertain to "Management of Road," the second and third to "Transportation or Freight Account."

IV. *Locomotive Power. The expense of renewals and repairs of locomotive engines and tenders, the cost of fuel, and the pay of enginemen and firemen, are nearly proportional to the distance run, and may be estimated at 30 cents per mile travelled by the engine.*

To do a business of 500,000 tons, it would require 25 engines, of which 20 would be in constant use, each being required to travel 25,000 miles per annum, at 30 cents per mile, is per engine, $7,500.

What then is the probable truth in this respect? In this item, the allowance is nearer the mark than any of the others. The amount of motive power is dependent on the gradients of the road, and the total cost, on its favorable position or otherwise, for cheap fuel, good track, facilities for repair, and on the skill and economy of the enginemen. In these particulars, the Pottsville road stands pre-eminent, and although $5000 is a fair charge per annum for an engine on most roads, it could here be made to do all that is required of it at per annum, $4,500

making a considerable saving in the nett result of a business of such magnitude, the circumstance which most elicits the economy of a railway—its expenses being always in an inverse ratio to its business.

substantial and level railway, doing exclusively a freighting business of 8 to 10 trains per day, or say 500,000 tons per annum, the expenditures would be annually about as follows:

*Repairs of Road.*

| | | |
|---|---|---|
| At $50 per mile, per annum, | 50,000 | |
| Attendance on water stations, | 2,400 | 52,400 |

*Motive Power.*

| | |
|---|---|
| 25 engines, of which 20 would be in constant use, at $4,500 each, per mile, | 90,000 |

*Transportation.*

| | | |
|---|---|---|
| Repairs to cars, 1500, cost $375,000 at 15 per cent. per annum, | 56,000 | |
| Oil and grease for cars per annum, | 11,000 | |
| Conductors and breakmen, 100, at $300 per annum each, | 30,000 | |
| Laborers at depots, 30, at $300 each, | 9,000 | 106,000 |

*Management.*

| | |
|---|---|
| Salaries to president, clerks at depots, etc. | 20,000 |

*Contingent Fund.*

| | |
|---|---|
| For accidents by fire, pensions, etc. | 11,600 |
| | $280,000 |

This divided on the tonnage transported, would give for each item the following proportions, and exhibits the favorable effect of doing a *large business* on a well appointed railway.

| | | |
|---|---|---|
| Repairs of road, etc. | | 10.50 per ton |
| Motive power, | 18 | |
| Transportation, | 21 1-4 | |
| Management, | 4 | |
| Contingent fund, | 2 1-4 | 45.50 |
| | | 56 cts. per ton |

or taking the gross receipts at $750,000 at $1 50 per ton, it gives a per centage thereon, of 36 1-2 per cent., or at most could it reach 40 per cent. or 70 cents per ton. This rate of expenditure moreover, is fully sustained by the experience in this country and in England, and on the London and Birmingham, doing a mixed business to the extent of nearly four millions of dollars per annum, it has by the last returns been reduced to 25 per cent. thereon, and

the received average for roads in England doing a respectable business, is about 35 per cent. on the gross receipts.

Thus is Mr. Ellet's formula found particularly inapplicable to the working of a railway doing a large freighting business. In forming it he has undoubtedly been misled, by the insufficient data generally supplied by railway reports, and by the little affinity or analogy between the roads themselves, not admitting of deductions from their operations, certain enough to be of any use in forming particular or separate averages. We think, however, the following extract from his essay, shows Mr. Ellet to be wanting in a true perception of the great purposes of this invaluable improvement.

"In course of time, when the velocity of burthen trains is reduced to 3 to 4 miles, and companies learn to know where and how to economise, it is probable that some of the items may be reduced; but time and experience have yet to determine how much."

Under such a restriction as to speed, why incur at all the great expense of a railway, when the turnpike and horse team would accomplish as much or more? The cost of a locomotive railway is nearly repaid, and its economy principally derived from the speed and then to couple it in that particular with the gate of a dray horse, strikes us a very incongruous association of ideas.

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[From the Journal of the Franklin Institute.]

FABRICATION OF GAS FOR LIGHTING FROM SOAP SUDS EMPLOYED IN CLEANSING STUFFS. *By* M. HOUZEAU MUIRON.

A few years ago the immense quantity of soap suds employed in the city of Rheims in preparing woolen stuffs was entirely lost. M. Houzeau Muiron conceived the idea of extracting from them the fatty matter, and of making an important application thereof. In fact, by submitting them to a regular purification, he has obtained a limpid oil, with which he succeeds in preparing the soaps in demand in commerce, while the residue of this purification serves for the advantageous production of a gas for lighting a part of the city.

The soap suds collected in the shops, where they have become saturated with grease and the impurities of the tissues, are poured together into a large basin which is capable of containing about 3,000 gallons. To decompose them, there is poured upon them 308 pounds of muriatic acid, or 154 pounds of sulphuric acid, first diluted with its own weight of water, and the mass is rapidly agitated, until the decomposition is complete.

Shortly afterwards a froth is seen to form, which at the end of

twelve or eighteen hours is sufficiently well separated from the water upon which it floats. Four fifths of this water is then run off, containing about one per cent. of sulphate of potassa which is utilized either by evaporating it in drying houses, or by running it off upon dry earth exposed to the air, which when sufficiently charged with the salt is washed. Directly after this operation, the basin is filled again with a fresh portion of soap suds, which float the fatty matter and permit it to be run off into a side tub. The product obtained is a mixture of unaltered oil, the acids, animal matters and a large quantity of water, which forms with them a species of hydrate. This water is disengaged by injecting several times into the mass a current of steam which heats it and facilitates its evaporation. The fatty matter is then run off into a boiler where it is submitted to a rapid ebullition, aided by continual agitation, which drives off the last portions of water. The product contains twenty or twenty-five per cent. of impure matters which color it and render it turbid. To purify it, it is poured into basins of copper and mixed with two per cent. of concentrated sulphuric acid. After two days the limpid oil comes to the surface, while the impurities are precipitated to the bottom.

The oil is carefully separated, and the deposit, when filtered through cloths in a press, gives still a large quantity of oily products, which are added to the preceding and made into soap by treating them with common soda.

The residuum is black and very thick; from it M. Houzeau produces the gas for lighting, but before introducing it into the retort, he liquifies it by means of the empyreumatic oil obtained in the preceding operation.

The gas thus prepared is purified by lime, and the water from the washing contains sufficient cyanide of calcium for the preparation of Prussian blue from it, by treating it with sulphate of iron and washing the precipitate with muriatic acid.

This gas possesses a considerable lighting power, and in order to apply it to the lighting of the establishments scattered throughout the city of Rheims, M. Houzeau has contrived a manner of transporting it, at the same time simple, economical and from danger.

F. Boudet.

Jour. de Pharm, et de Chim., May, 1842.

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## MR. VIGNOLES' LECTURES ON CIVIL ENGINEERING.

*Lecture* 12.—*Railway Estimates.*—This lecture had reference to the consideration of estimates, as applied to railways—that is, to ascertain lineal dimensions, superficies, and cubic contents, and, affixing the proper rateable prices, to work out the monied results. The professor said, that, probably, the most ready way to give a general idea on this subject would be to go briefly over the several heads to be considered in framing an estimate. It was assumed that proper plans and sections of the work had been prepar-

ed in a skilful manner beforehand, Mr. Vignoles strongly insisted on the necessity and importance of having all such documents furnished on a much larger scale, and with vastly more attention to accuracy and detail, than had often hitherto been the case, particularly for parliamentary estimates, observing, that erroneous data and calculations could not but result from a neglect of this rule: and he stated, that, although many of the standing orders of parliament were annoying in some respects, yet the principle on which they were framed, went to compel a compliance with forms, in doing which, greater previous investigation and accuracy of plans and sections, became absolutely indispensable.

The *quantity of land* required formed naturally the first item of an estimate. It was but seldom, indeed, that the very small economy of taking land for one line of railway only was adopted. To a given breadth, therefore, for a double line—say, from eight to ten yards—must be added the necessary allowance for fencing and ditching—say, three yards on each side—making a constant breadth of fourteen to sixteen yards of land throughout, independent of the necessary slopes in excavations and embankments: the additional quantity for these, depends, of course, on the depth of the cutting, or height of the bank, in the various places, and on the ratio of the slopes of the earthwork. Suppose, in a cutting or banking of ten feet, this ratio to be one horizontal to one perpendicular, then, such slopes of one to one require ten feet additional breadth of land on each side—together, twenty feet—viz., twice the depth or height to be added as a further breadth, beyond the constant one for the railway and fencing. In like manner, for slopes of one and a half, two, two and a half, or three to one respectively, multiply the varying depths or heights of cutting or embanking by three, four, five or six, as the case may be, for the necessary augmented breadth of land due to the slopes, along their several extents; and thus, from the lengths measured, and the heights figured, on the section, the varying quantities of land are obtained, multiplying length by breadth, and reducing the areas to acres and parts for agricultural districts, and to square yards for land in towns and their immediate vicinities. For the prices to be assigned to these superficial quantities, the engineer must depend on the land valuer, who is also to judge of the amount of contingent damages. On an average, the actual quantity of land for a double line of railway, including the slopes of earthwork, may be taken at ten acres to the mile, but the precise areas must be ascertained in detail in the way explained. The cost of land for many of the leading lines of railway had been as much as £5000 per mile for the whole of their length. The cost of land for lines at a greater distance from the metropolis was less—still, from the numerous contingent after-charges, in respect of land, the sums were large, and had often far exceeded the original estimates.

The *fencing of the land* comes within the province of the engineer, though it is sometimes comprised in the item of land. The mode of fencing must always be regulated upon the custom and

materials of the country. Dry stone walls, earth mounds with furze hedges, posts and rails, quickset hedges, and broad side-ditches or drains, are the principal kinds of fencing through agricultural lands; walls of brick or masonry, set in mortar, are generally called for through towns or building land. The several lengths of each of these are ascertained from the plans; the prices are obtained in the localities. Including farm gates, the cost of fencing varies from 1s. 6d. to 3s. per yard lineal in the country. In the vicinity of towns, for stations, etc., the price will vary from 5s. up to 10s. per yard, according to circumstances, which it must be the business of the engineer to ascertain.

The third item is usually that of *earthwork*—that is, to reduce the undulating natural surface of the ground to the railway level or gradient, by cutting through hills, and filling across valleys. Mr. Vignoles having, in the first course, entered at large into the consideration of earthwork, thought it unnecessary to say much here. The price of the earthwork depends abstractedly on the average work that an able-bodied man can perform in a day, in various soils —this it should be the study of the engineer to determine. The mere price to the workman, for getting and filling, may be taken at from 2d. to 5d. per cubic yard, for the various kinds of sands, gravels, or clays; and from 6d. to 2s. for harder materials, rock, etc., but, in addition, various other matters are to be provided—barrows, planks, wagons, temporary railways, etc.—the present modern practice in moving large quantities of earth is vastly different to what it was in this country thirty years ago, or to what it still is on the continent, more particularly in the greater distance to which the material is carried; these several distances between the excavations and the points of depositing them, either into embankment or to spoil, must be ascertained from the longitudinal section, and a careful examination on the ground—these distances are technically called *the lead;* for distances under a quarter of a mile, the prices are higher, in proportion, than for longer distances. Taking the average description of soils, and the average distances, 1s. per cubic yard may be taken as a covering first estimate, upon the whole number of cubic yards of excavation or of embankment, whichever may be the larger quantity shown upon the section. The quantities of earthwork in a railway, on an average per mile throughout the whole distance, might be taken as a characteristic of its cost, so far as mere construction went, independent of carrying establishments, stations, and land, over which items the engineers seldom had control. Mr. Vignoles said it would be very interesting to have an abstract of the quantities and cost of the earthwork, distances carried, etc., on all the railways, and indeed, of all the other items of the works, as actually executed; they would become valuable precedents for future estimates, particularly if accompanied by explanations of the circumstances under which the operations were carried on. The great haste with which many of the railways were executed, while the late powerful excitement lasted, had added greatly to the cost, by raising the price of labor. Mr. Vig-

noles stated that he had already given some such abstracts of the railways that had been executed by him, or under his directions, and he was prepared to give more, and he hoped that other engineers would follow his example, as it could not but be very satisfactory to the proprietors of the different concerns, as well as a justication to the engineers themselves, and to the directors, that they could go into the minutest detail of expenditure. The professor then gave abstracts, in round numbers, of the quantities of earthwork on many of the principal lines of railway, as well as could be ascertained from the sections. He mentioned the North Union railway, twenty one miles long, with 125,000 cubic yards of earthwork per mile, at an average cost of 10¾d. per yard, including all extras and contingencies. The Midland Counties, 57¾ miles, with 100,000 cubic yards of earth per mile, at an average cost of 13d. per yard, including slips and all charges, the soils nearly the same in each, and the average lead nearly alike—viz., one mile—attributing the difference to the great haste and great demand for labor in the latter. The mean of these would be now a fair estimate.

Having estimated for the cost of obtaining the artificial bed of the railway, the next item would be the *Bridging and Masonry*—that is, to restore the previously existing communications of roads, canals, or other railways, the passage of rivers, watercourses, etc. etc., by viaducts, aqueducts, ordinary bridges, culverts, drains, etc., and often by heavy retaining and breast walls. Under this head came the bridges of brick, timber, or iron;—in very marshy countries, where the foundations are likely to be bad, and the drainings liable to be affected, timber may be resorted to, and used in the shape of piling, with cross beams to sustain the rails across the openings, avoiding thus the cost of arches, abutments, and wing walls. The ascertainment of the several superficial or cubic quantities in each of these different constructions, is a matter of simple mensuration from the working drawings. The attachment of prices to these, in all their various details, with sufficient accuracy, depends on the mature judgment and experience of the engineer; and it is by a long course of careful study and observation that the young student, in his employer's office, and on his works, can alone hope to acquire this knowledge. It was but too common, in making estimates, to fall short in this item, particularly in the number of occupation bridges, which, owing to the complicated holdings, improvements, etc., had to be provided for to a vexatious extent, or bought off. The masonry is generally in proportion to the earthwork, and in many cases has happened to be of nearly the same amount of cost. The average number of bridges on a main line of railway might be taken at five for two miles. Diversions and embanked approaches of roads, gravelling or metalling the new surfaces, and the contingent operations, should be separately calculated. They are included under the head of fencing, of earthwork, or of bridging, or kept as a distinct item, according to the practice of the engineer, but they form a large sum, varying from 100*l.* to 500*l* per mile, according to circumstances, and, in preliminary esti-

mates, are too often omitted, or are put into that refuge for all deficient items—contingencies.

The item of *Upper Works* in general, or *permanent way*, had been gone into so fully in the recent lectures, that it was not necessary here to do more than mention it, as forming a leading point in considering estimates. It is usual to add 10 per cent. upon all the items of the estimate, properly belonging to the engineer. Besides these were the preliminary expenses of surveys and Act of Parliament. The management, including cost of conveying, etc., and all salaries and expenses of direction, office, engineers, solicitors, etc., etc. Then came the expenditure on the stations, engines, carriages, repairing and building shops, fittings, and all the carrying establishment necessary for passengers, also for goods and for warehouses, wharfs, and other accommodation. It was in them the heavy extra expenditure of railway capital mostly went, and which, in the early stages of the railway system, could not be properly judged of. By way of summary, Mr. Vignoles said he would give, in his next lecture, the actual cost of one or two lines of railway which had come under his direction, and which might be useful by way of reference in making out estimates on other occasions, though the construction and working of railways must be regulated on much more economical principles than had hitherto been the case, or no more of them would be undertaken.

*Lecture* 13. In continuation of the observations on *Railway Estimates*, which had been commenced in the last lecture, Mr. Vignoles observed that, having therein gone fully into the items of *construction* of railways, he had only glanced at the very necessary provision to be made for the efficient *working* of them—viz., the *Stations and Carrying establishment*, upon which he would say a few more words, for it was mostly under this head that the chief causes—or, rather, the chief excuses—for extra expenditure, or excess of estimates, had arisen. Properly speaking, this item, so costly, and yet so indispensable, should be taken as falling on a railway company, not as proprietors of the road, but as carriers—the distinction being, that if the railway was let on lease, as canals have been, or if every body could carry on the railways, as they do on the canals—if, in short, public safety and public convenience, and generally necessary arrangements, did not make it imperative, or, at least, highly desirable, that the railway companies should be carriers (of passengers, at all events,) the expense of stations and carrying establishment would not fall on them, though they must still be incurred by some parties, before the railway can be brought into profitable operation; nevertheless, the public, who are to use and be benefitted by the road, having, after all, to pay in one shape or another, are greatly interested in a proper expenditure, any excess of which is sure to be felt in increased charges or in diminished accommodation, until the grievous expenditure of a rival line is introduced. In analysing the cost of *Stations*, it is obvious that the land always forms a prominent item, for, being near towns and populous places, it is to be bought by the yard, and not by the acre—

building land, villa land, etc., instead of mere fields. Hence, it will not be surprising, if it is found that the cost of the land, for the stations only, on many of the great lines, has amounted to as much as one-third of the whole cost of land for the railway. The *buildings* erected at stations may be divided into three classes—those for the accommodation of the passenger trffiac—those for the goods, minerals, etc.—and those for the repair and maintenance of the engines, carriages, etc. At principal towns, therefore, large and distinct establishments must be erected; and, on long lines, a principal central depot for the engines, is often required in addition. At the minor and road stations the whole may be grouped together under one roof. In no department of expenditure have so many differences, and so much useless extravagance in construction and arrangement been displayed, as in the buildings at stations: and hundreds of thousands of pounds have been absolutely thrown away from want of sufficient forethought and consideration; and by erecting enormous masses of buildings, either at the wrong places or in an injudicious manner. It was better to wait until the character of the traffic was ascertained, before making such expensive permanent establishments, and then to increase the accommodation by degrees. As an example of a moderate expenditure under this head, Mr. Vignoles mentioned some particular instances, and went somewhat into detail. At the terminus of a railway in a manufacturing town with 80,000 inhabitants, there had been an expenditureof £9,500 for the passenger buildings, sheds, etc.; £5,500 for goods' warehouses; about £2000 for the mineral traffic; and about £3000 for fixtures, turnplates, etc.—say, in all, about £20,000 exclusive of the land, which had amounted to a very large sum, upwards of £13,000, including a good deal of spare space, existing buildings, etc. At a smaller town on the line, but with some extent of goods' traffic, the cost for passenger buildings, sheds, etc. was £2500; for merchandise accommodation, £3500; turn-plates, fixtures, tools, etc., £1000; land about £3000. On the same railway the cost of six or seven various minor road stations, including water tanks, coke and engine sheds, tools, etc., was £3500; land about £1500; sundries on the whole line about £1000—being a gross expenditure of £50,000 on station, land, and buildings, for a line of about twenty two miles, which is at the rate of £2273 per mile; and the corresponding carrying establishment of engines tenders, etc. (for passenger traffic only), was about £19,000; for passenger carriages of three classes, horse-boxes, trucks, etc., about £13,000 (the wagons for merchandise, coal, etc. as well as the engines, etc., being provided by carriers on the line, who provided their own carrying stock); and the necessary buildings for repair and maintenance of engines, carriages, etc. with tools, fixtures, etc. about £12,000—making a gross cost of £44,000, or £2000 per mile. The whole of this concern having been arranged with the strictest regard to economy, may be taken as a fair average, and it will be safe to say, that £4000 per mile for an effective carrying establishment, with the necessary stations, is a moderate sum. For

lines of less traffic, if of considerable extent—as, for instance, say for some of the long lines from the present railway termini in the north of England, to either of the principal towns in Scotland, a smaller amount might be sufficient; but Mr. Vignoles considered that it would be unwise to estimate a smaller expenditure than that of £3000 per mile for *Stations and carrying establishments*, on a line to be worked by locomotive engines, and it would be much safer to take £4000; on either of these sums, £1500 per mile for the locomotive stock and buildings must always be estimated, and about £500 per mile for the carriage department—leaving from £1000 to £2000 per mile for the stations, according to the extent of accommodation; keeping the instances of extraordinary outlay on some of the principal railway lines as examples to be avoided, and not to be imitated, or referred to, as necessary.

Under the last head of *Management*, came all the various and miscellaneous items of expenditure, between the first concoction of the project, to the closing of the capital account. The preliminary expenses of examining the ground, levelling, surveying, maps etc., and all the formalities in the engineer's department, to enable application to be made to Parliament; the ascertainment of the traffic, revenue, travelling and other expenses of various kinds, etc., generally undertaken by the secretary; the valuation of land, etc. by the surveyor; the collections of the names of owners and occupiers, notices to them, applications for their assents, etc., and the management of the Bill throughout all its stages, falling to the charge of the solicitor. All these must be incurred before a spade was put into the ground, and had heretofore varied from £500 to £1000 per mile, according to the facilities afforded, the opposition encountered, the length of the line, etc. In future estimates, it was to be hoped this item might fairly be put, as not exceeding the smallest of these sums. Then came the setting out of the line, the detailed levels and surveys, and all the office work of the engineer, until the works are put into the hands of the contractor. The minute valuations of the property to be taken, and the juries, references, conveyancing, stamps, and all the various legal steps until the company are put into full possession. Then the office establishment for regulating all the financial and ministerial affairs, and the temporary arrangements, police, lawsuits, and legal and illegal charges of all kinds, taxes and rates, interest and commission to agents and brokers, travelling expenses, salaries, and a great variety of disbursements of a miscellaneous kind, which, in the aggregate amount to a large sum. The whole of the outlay thus coming under the head of *Managemsnt* has varied from 5 to 10 per cent. on the gross cost of the railways hitherto executed, according to their extent, and the amount of capital embarked, and especially according to the degree of vigilance exercised to keep down expenses, which depends chiefly on the director or secretary, or under whatever name the acting manager of the company may superintend. Judging from the examples past, and the deep impression which has been made on the public mind of the necessity of economy in every de-

partment, Mr. Vignoles thought 5 per cent. might be estimated hereafter, unless the lines were very short, and the capital small.

In recapitulation, the Professor observed, that the young engineer should always keep in view, for his estimates, the preceding great divisions of the cost—viz., *land*, including the damages and fencing—*earthwork*—*works of art* (bridging, masonry, etc.)—*upper works* (the permanent railway proper)—*stations and carrying establishment*—*management*—and having, in his first estimates, allowed amply for each of those items under their several heads, he should add at least 10 per cent. for unforseen contingencies. Some of the preceding items would be common to almost all railways, and others, of course, would vary greatly, according to local circumstances, chiefly regulated by the amount of earthwork; for as that is heavy, so the works of art become costly, since the works of art are merely to restore the existing communications of the country, and the natural or artificial water courses and drainage to their state before disturbed, or as near as may be, and that to an extent in exact proportion to the civilization and improvement of the country, to enforce all which stringent clauses are inserted in the acts of parliament, and plenty of persons are always on the watch to enforce them. Mr. Vignoles observed, that the land, levelling of the ground, and restoring of communications, might, on the average, including contingencies, extra land, etc., be taken as forming about 50 per cent on the total outlay of railways hitherto executed. But, referring to the items the professor had gone over in detail in previous lectures, it appeared that, when proper economy and circumspection was used, the necessary cost of the railway proper—that is, the necessary quantity of land for the road only, a good substantial set of upper works for a double way, and a complete and effective carrying establishment—might, and had been, obtained for £10,000 per mile. All beyond is expenditure to obtain gradients, more or less perfect, and Mr. Vignoles thought that the great error all engineers had hitherto committed, the cardinal mistake—of which he himself was far from guiltless—was, seeking to make railways, intended, as they were chiefly for passengers, *too perfect*—that is, of cutting down his, and filling up valleys to too great an extent, on the erroneous supposition that the engines were always to carry *maximum* loads, which was very seldom the case, and never would be so on lines at a distance from the metropolis, particularly such as the lines into Scotland, previously mentioned. In short, the Professor insisted that the engineer should, in such instances, and for the cross railways, which he yet hoped might be introduced, make the gradients and curves much less theoretically perfect; and that the amount of expenditure, beyond the above stated necessary one of £10,000 per mile, should be reduced to the very *minimum*; and he considered that henceforth an average of £15,000 or £16,000 per mile, and a *maximum* of £20,000, or, in very extraordinary cases, indeed, £25,000 should be looked to for the construction of double lines of railway in any country, but that most cases, of light traffic, and consequent adaptation of gradients,

for single lines, a sum of from £7000 to £12,000 per mile would be the limit of total expenditure. Mr. Vignoles concluded by observing, that the preceding abstracts were deduced from very detailed accounts, which had been arranged on a uniform system, and kept from the very commencement of each undertaking, so as to be available, at any time during the progress of the works, to show the exact state of the expenditure; and had been finally wored out to the nearest thousand pounds, as above. And the professor expressed his great hope and expectation that this example would be followed, and that similar accounts would shortly be forthcoming, of the corresponding items of cost on all the principal railways in this and in other countries, more especially where complaints of improper excess of expenditure over estimates (well or ill-founded) had been charged, for the publication of such accounts—and the more in detail the better—would be the most complete defence of the directors, and the most satisfactory explanation from the engineer, and alike valuable, as statistical information, to the country—as salutary guidance to the capitalist and speculator—and as valuable information and warning to the old as well as to the young practitioner.

The preceding is a very brief outline of this interesting lecture, and following, we believe, is a correct abstract of the cost of the two railways quoted by Mr. Vignoles.

*Comparative abstract of the cost of two principal lines of railway, under the general heads of expenditure, as deduced from the very latest accounts of actual expenditure, brought out to the nearest round numbers.*

| MIDLAND COUNTIES RAILWAY. [57¾ miles. | | | | Heads of expenditure. | NORTH UNION RAILWAY. [25 miles.] | | | |
|---|---|---|---|---|---|---|---|---|
| Pr. cent whole cost. | Cost pr. mile. £ | Total cost. £ | | | | Total cost. £ | Cost pr. mile. £ | Pr. cent whole cost. |
| 12 | 3463 | 200,000 | (790 acres) | Railway land, and damages | (320 acres.) | 50 000 | 2000 | 8 |
| 3 1-2 | 1004 | 58,000 | | Fencing, gates, roads, etc. | | 20,000 | 800 | 3 1-2 |
| 18 1-2 | 5455 | 315,000 | (5,700,000 cubic yards) | Earth work | (2,900,000 cubic yards) | 125,000 | 5000 | 20 1-2 |
| 15 | 4364 | 252,000 | [tons | Works of art, of all kinds | | 125,000 | 5000 | 20 1-2 |
| 23 | 6822 | 394,000 | Upper Works £215,000—(17,670) 179,000 | Iron rails and chairs | (6885 tons) £68,000 Upper works 62,000 | 130,000 | 5200 | 21 |
| | | | £ 51,000 | All other materials, and labor | | | | |
| | | | 168,000 | Station land and damages | £18,000 | | | |
| 21 | 6147 | 355,000 | Stations and carrying establishment 75,000 | Buildings, fittings-up etc. | 48,000 Stations and carrying establishment | 100,000 | 4000 | 16 1-2 |
| | | | 61,000 | Engine, etc. stock | 20,000 | | | |
| | | | | Carriage, etc. stock | 14,000 | | | |
| 7 | 2182 | 126,000 | | Management, law, interest, etc. | | 60,000 | 2400 | 10 |
| 100 | 29,437 | 1,700,000 | | Totals | | 610,000 | 24,400 | 100 |

ON STRAIGHT AXLES FOR LOCOMOTIVES. By Prof. Vignoles.

The fatal results of the late terrible catastrophe on the Paris and Versailles Railway (rive gauche) has drawn the attention of the public in general and engineers in particular, to the causes which produce such fearful effects; and the breaking of the axle having been prominently put forward as the original occasion of this and many other railway accidents, it seems desirable that a dispassionate inquiry should be instituted, and an endeavor made by calm discussion to elucidate truth.

It is not intended, in the present note, to allude, except in general terms to the above accident. It is clear that the breaking of the axles in this case was not of itself sufficient to produce such a disaster. It was not the driving axle that broke, but the fore axle of the small four-wheeled engine; and it was with great regret that I perceived the cause of the accident attributed to the principle of construction of the machine. It must be quite evident to all engineers who have attentively read the details of the accident on the Versailles Railway, and of the one that occurred on the London and Brighton Railway soon after the first opening, that the same causes were in operation, and greatly aggravated the sad results in both instances, viz. the coupling together of two locomotives engines of unequal power and of different constructions, the smaller in advance:—On both occasions a long train of heavily laden carriages were moving at very high velocities on a falling gradient; on the occurrence of the accident to the smaller engine in front, the diver suddenly turns off the steam; the man on the larger engine behind, from whatever cause, does not act simultaneously, and a few seconds continuance of the vast unchecked momentum of the heavy engine with the steam on, overwhelms the smaller machine, and the whole train is overthrown. It is scarcely possible to regulate this unity of action, more especially in the locomotives of unequal size and construction. Why are engines propelling from behind objected to? Evidently because, in the event of any obstacle occuring in front, a simultaneous check cannot be given to the rear engine, and it drives the carriages forward upon each other, at the very moment when the opposite effect is required.

There is, therefore, quite sufficient to account for the accidents in both cases, without raising the ridiculous and exaggerated cry against the fourwheeled engine *per se*. As respects safety to the travelling public, I believe, and I venture to say, in common with a great many engineers who are not manufacturers, that there is no material difference between the four-wheeled and the six-wheeled locomotives; but that the consideration most generally influencing the selection is that of the distribution of the weight of the machine so as to impinge less injuriously on the rails; and it is well understood that the system of the double trucks, or eight-wheeled supports for locomotives, tenders, &c., as adopted on the American Railways, has been introduced on this principle, the rails and upper

works in that country being in general much lighter than with us.

The real and important point, and which seems to have been quite lost sight of in the vivacious discussions on what I would call the minor question of the number of wheels, is, whether the *cranked axles* for the driving wheels of locomotive engines ought not to be abandoned, and whether driving axles should not be always made straight. The extent of prejudice in favor of cranked axles is most extraordinary. The very great increased expense incurred in making and strengthening them, the additional complexity and cramping into narrower space of all the moving parts of the machinery, and the consequent wear and tear and inconvenience involved by their use, to say nothing of the augmented risk, far overbalance, in my opinion, any theoretical advantages alleged in their favor, but which advantages and superiority, in practice, over the straight axle engine, I could never discover and wholly deny. Eight years since, after a hard struggle with the manufacturers, straight driving axles were adopted for the locomotives on the Dublin and Kingstown Railway. On that line, especially on Sundays and on holidays, the traffic is quite equal to that on any railway yet open. Trains of from 12 to 15 carriages (but with one engine only) are at such times sent every quarter of an hour from each end of the line; and there has been no instance of accident from any cause connected with the form of engine or axle, or with such frequent departure of heavily laden passenger trains; and the finance accounts of the Company show that the cost of locomotive power, repairs, etc. is below that of other lines using cranked axles; nor do I know of any cause of objection to the straight driving axle, after seven or eight years experience of their use, without, I believe, a single instance of failure which fully justifies my opinion of their superiority.

On other railways I have been connected with I have not always been so fortunate as to have succeeded in banishing the cranked axle. As sometimes happens in Governmental and political struggles, the votes of the controlling body have overpowered the opinion of the executive, where a difference among members of our profession have given opportunities for Directors to exercise their own discretion; and cranked or straight axles, four-wheeled or six-wheeled engines, have been alternately adopted according to the prevailing ideas of the majority of the several railway boards.

I have, however, reason to believe that several engineers of high standing are becoming converts to the straight axle, and I congratulate the public on it, as a very important step in the right direction.

In respect to the attention to be given to the manufacture of axles it is impossible to pay sufficient regard to the importance that the scrap iron should have gone through the same processes in its previous different stages. On this subject I hope some of the experienced manufacturers who are present will throw some light, especially on the details, for on the abstract principle there can be no dispute, although I suspect it is greatly neglected, in particular

for ordinary carriage axles, and probably only scrupulously attended to in forming the driving axles of locomotives.

Some of the French engineers, however, have, within a very recent period, suggested that we must seek for the causes of the often unexplained rupture of axles in another way. M. Frangois and Colonel Aubert have both lately read, at the Royal Academy of Paris, papers on the subject, and attribute the cause of the fracture of the axle of the engine on the Versailles Railway to the iron having been crystallized from the action of heat or magnetism. In support of this opinion it is stated that the axle broken was formed of the best iron, and was of sufficient dimensions; and that the fracture had a decided crystallized appearance: and I have indeed myself often observed the same character in broken axles, so much so as to induce me to fancy sometimes that they had been formed of cast iron.

M. Frangois stated in his paper that he had made a long continued series of experiments, and had observed that a magnetic action on iron in a state of fusion will produce similar effects, and change the small and closely adhering particles into coarse and large crystallized grains, depriving the iron of its compact character. This talented mineral engineer inferred that the action of heat upon axles moving at high velocities might produce the same effect. Both M. Frangois and Colonel Aubert seemed to be of opinion that the only real precaution was to change the axles of locomotive engines so frequently as not to give them time to undergo the crystalline change; suggesting, however, that iron that had been previously worked up should alone be employed for axles, and not new iron, which had more of a vitreous character, and was more susceptible of crystallization.

Since this paper was prepared, I have reason to believe that this crystallization of wrought iron has been noticed by some of our eminent manufacturers, whose opinions there may be an oppartunity of obtaining; and if it be, as Mr. Fairbairn informs me, that cold swaging will crystallize hammered iron, the shocks that locomotive engines sustain in their rapid transits may well be put as a great cause of this remarkable change.

It is, however, clear, that to remedy and replace straight axles is much easier and cheaper than to deal with cranked axles, and I venture to state it as my humble opinion, that as much ingenuity and talent is thrown away in arranging locomotive engines with cranked axles, and in perfecting the manufacture of those "crooked billets," as there was in rolling iron into undulations for fish-bellied rails; which are now almost as much forgotten as, I doubt not, the cranked axles for locomotive engines will one day be.

*Remarks.*—Mr. Hodgkinson was certain, from the results of his experiments, that a succession of strains, however slight, would produce a permanent deterioration of the elasticity of the iron.—Mr. Fairbairn had been told by the engineer on the Leeds line, that he considered all crank axles to be constantly deteriorating from percussions, strains, etc., and that they should be removed and replaced

by new ones periodically, to avoid danger of fracture.—A discussion arose as to whether the crystaillized appearance observed in fractured axles arose from defects in the manufacture, in the quality of the iron, or from the effects of working, either by percussions, strains, or magnetic action.—Mr. Grantham, although a manufacturer of cranked axles, admitted that straight axles were less liable to break. Cranked axles, from the way in which they were welded together and shaped, were rendered weak and liable to fracture. On other grounds, however, he believed that the cranked axles were preferable, as they produced a steadier motion, and much heat was saved. Mr. Garnett believed that more straight axles had broken than cranked ones.—Prof. Willis showed the effect of vibration in destroying molecular arrangement, by reference to the tongues in musical boxes, etc.—Mr. Nasmyth believed that the defects in axles etc., arose in the manufacture, especially from cold swaging and hammering, and also from over-heating in welding, all of which causes injured the toughness of the iron. In small articles he found great advantage from annealing; and he believed that axles might be annealed very cheaply, and would be more serviceable. He disliked the fashion of referring all unaccounted phenomena to magnetism and electricity, although he was convinced that very singular electric phenomena accompanied the transit of locomotives and the rapid generation of steam. With this was connected the non-oxidation of rails, where the traffic was in one direction, and the rapid oxidation when the same rails were travelled over in both directions, as in the Blackwall railway. He had also observed that brasses, in some cases, had from friction entered into *cold fusion* —that is, at a heat not perceptible to the eye, a complete disintegration of the molecular structure had taken place, and he had seen the brass spread as if it had been butter or pitch. He had no doubt that this arose from electricity, but had not ascertained the fact from experiment.—Mr. Fairbairn stated, that in hand-hammered rivets the heads frequently dropped off, and presented a crystallized appearance, while those compressed by machine were sound. He found that repeated percussions, from the rivetting, hammering plates, etc., induced magnetism in iron boats.—Mr. Vignoles could not, from his experience, agree to Mr. Nasmyth's theory of the oxidation of rails by single traffic, as the railway from Newton to Wigan had been single for a long time, and was as bright as the Manchester and Liverpool. The Blackwall railway was not an analogous case, as no locomotives were employed.—Mr. Roberts disbelieved the deterioration of axles by work; he would rather trust an old axle than a new one. He believed cold swaging and hammering to be the chief causes of mischief. In fact, if axles were sent out sound and well manufactured, they would rather improve by working.

Mr. Nasmyth at a subsequent meeting gave some valuable practical suggestions on the cause of breaking of axles, which we purpose noticing next month.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

TWELFTH MEETING, 1842.

We are indebted for the following report partly to our own correspondents, and partly to the *Athenæum* and the *Manchester Guardian*—the latter paper gave a very copious account of the whole of the proceedings, including the speeches delivered at the dinner.

REPORT FROM THE COMMITTEE ON RAILWAY SECTIONS,

presented by Professor Vignoles.

A grant of 200*l.* from this Association was made at the Glasgow meeting in 1840, on a joint application from the Geological and the Mechanical Sections, towards obtaining profiles of the various railways, chiefly with a view of putting on record (before the slopes of the excavations become soiled over and covered with vegetation) the geological appearances and strata developed in the many vast openings made through the country by the operations of modern engineering. At the Devonport meeting last year a renewal of the unappropriated balance of the first grant was made; the whole sum has since been expended, and the results are now laid before the Sections originating the subject, in the shape of the numerous working plans and sections of several of the railways, and of the enlarged parts of the profiles of the excavations.

In obtaining these the Committee appointed by the Association have great pleasure in reporting, that they have been aided in the most effective and satisfactory manner by all the railway companies to whom they have applied, and also by their several officers, the engineers in particular having taken extreme pains and great interest in forwarding the views of the Association. When so many parties have thus zealously co-operated, it might be almost invidious to name one without specifying all; but in particularly mentioning Mr. Swanwick, the engineer of the North Midland Railway, the Committee wish to do so for the purpose of remarking on the great pains taken by that gentleman in marking, as his works went on, all the geological details of the cuttings, which pass through so interesting a region, and which has put into the possession of the Committee a vast extent of most valuable records of the kind sought for, and which at the same time forms a most striking example, well worthy of imitation, of the combination of engineering and geological information, applicable for economic purposes.

The Committee were not at first able to organise a system of working the grant to their entire satisfaction; but they found after some experience that with the favorable disposition shown by all the railway companies, they might (without increasing the expense,) by degrees and in no great time, be able to form an interesting and valuable collection, not only of the sections of the excavations of the railways, but of the whole of the plans and profile of all the lines, which, concentrated in one public depository, and open to the inspection of all scientific and literary bodies and individuals,

and to the public in general, under proper regulations, would be of high interest. In fact such documents were almost necessarily required, as the mere indices wereby to identify the particular geological profiles; and so useful and important is such a collection likely to become, that it is not unreasonable for the Committee to hope and believe, that after another year's experience shall have matured their arrangements and perfected their proposed system of records, and brought down the expense to a certain and moderate rate per mile, the subject may be taken up by Her Majesty's Government, and made to form part of the great geological survey of the United Kingdom, conducted by Sir Henry de la Beche, in connection with the trigonometrical survey now carrying on by Colonel Colley and the officers of the crops of Royal Engineers. The committee, therefore, are not without hopes that the geological and mechanical Sections will again unite in applying to the General Committee for a further grant of 200*l.* at the present meeting, to enable them to complete the organization they have began.

The documents which the Committee have to submit are the following:—

1st. Plans and sections of the whole of the Midland Counties Railway from Rugby to Derby and Nottingham, about 58 miles. Enlarged sections of the cuttings on that railway, prepared to be filled in geologically. The chief characteristics of this district are the gypsum beds, commonly called plaster of Paris, and the hydraulic lime, well known to engineers as the Barrow lime.

2d. Plans and sections of the whole of the North Midland Railway, from Derby to Leeds, about 72 miles. The entire of the geological details have been laid down on the working sections of the cuttings; but as it has been considered by the Committee that a uniform system should be observed enlarged sections have been prepared, on which, as on the similar sections of the other lines, the strata should be delineated. It may be observed here, that these enlarged sections are on the natural scale of 40 ft. to an inch, that is, the vertical and horizontal scale are alike, which is not always the case in ordinary geological sections, and very seldom so with the working sections, for earth work and similar engineering purposes. This railway intersects the coal districts for many miles; and is replete with interesting objects.

3d. Plans and sections of the Manchester and Leeds Railway, from Manchester to Normanton, about 50 miles. These latter are not quite finished, but will be so before the close of this meeting. Enlarged sections of a considerable portion of the excavation on this railway, are filled up with the geological details.

4th. Enlarged sections of the excavations on the Glasgow, Paisley, and Greenock Railway, about 22 1-4 miles, with the geological details.

5th. The same for the Manchester and Bolton Railway, about 10 miles containing full details of the strata where the remarkable fossil trees were found, and of the trees also, models of which are in the exhibition room at the Royal Institution in Manchester. The

liberality of this company will afford several opportunities for the members of the Association to visit these trees, and the particular profiles of the excavation where they are, will remain in the Geological section, or in the Royal Institution, where the models are.

6th. Enlarged sections of the Hull and Selby Railway, about 30 1-2 miles, with the geological details.

Some other enlarged sections are stated to be preparing for the Committee, but they have not come to hand in time for the present report.

These records, according to the directions of the Association, will be deposited in the Museum of Economic Geology, in London, where they may at all times hereafter be usefully referred to.

In conclusion the committee cannot refrain from observing that the documents thus collected are equally important and interesting to the philosopher, the geologist, and the engineer. To the philosophical or theoretical investigator they present the curious and varying features of the crust of this portion of the globe; to the practical engineer they offer a memorial of the experience of the profession, whence many a serviceable lesson for future operations may be learned; whereby difficulties and expense may be hereafter avoided and diminished, and from which valuable information may be derived for the appliance of materials in constructions, it being one of the great arts of the engineer to avail himself of the most immediate natural resources which he has to displace in one instance, and to apply them usefully in another, when in juxta-position. And, on the other hand, the minute variations of strata and soil thus accurately delineated, and referred to well defined altitudes with respect to the general surface of the ocean, become of the very highest interest to the geologist, and no less so to the mining engineer, more especially on the lines of railway intersecting the coal and mineral districts, where, in numerous instances, labor, directed by science and sustained by commercial enterprise, has laid bare in deep chasms the secrets of Nature, and the stores whence this country has derived so many advantages, and whose well-directed energies have drawn from our mines of coal and rude metals that abundant wealth and prosperity which the more splendid productions of Potosi and Mexico have failed to bestow on their possessors.

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## INSTITUTIONS OF CIVIL ENGINEERS.

April 26.—The President in the Chair.

"*A description of a new arrangement for raising Ships of all classes out of water for repair, proposed to replace the Graving Dock or the Patent Slip in certain situations; with observations upon the other methods used at different periods for this purpose.*" By Robert Mallet, M. Inst. C. E.

This communication describes an apparatus proposed by the au-

thor as a substitute for the graving dock or the patent slip, in situations where such constructions would be too expensive, or an inappropriate locality prevents their adoption. It reviews the principal methods hitherto in use—such as stranding by bilge-ways, careening or heeling over, lifting by the camel, the graving dock, the floating dock or caissoon, the screw and the hydraulic docks (both American inventions,) and Morton's patent slip; it enumerates the localities for which each of these inventions is most applicable, and then gives the objections to them. The author then describes the general principle of his invention to be, the diffusion of the the load or strain over the greatest possible number of fixed points avoiding casual and unequal strains; that there should be uniform motion, with a power proportioned to the resistance. In providing for this, the joggle-joint is used throughout. The machine consists of a platform, supported upon a series of frames with joints at each end, attached at the lower extremities to fixed points in the foundation, and at the upper ends to the under side of the platform, which is traversed by a series of beams, to the ends of which are fastened rods connected with rollers, working in grooves along a suspended railway on the cantilevers of two jetties, which are built to form the sides of the aparatus. A chain connected with all these rollers traverse in each suspended railway groove, and the power of a steam-engine and wheel-work, being applied after the vessel is floated on the platform and made fast, the frames raise the platform and vessel together gradually out of the water, permitting free access all round the ship; and when the repairs are completed, the whole is again lowered into the water. It is contended that many practical advantages would arise from this system—that the ship would not be strained, that time would be gained, and that it is superior to the ordinary methods now practised. The calculations of the leverage, the division of the load over the fixed points, etc., are given in detail, and the paper is illustrated by a series of elaborate drawings and a complete model of the apparatus.

*Remarks.*—Mr. Rendel thought that credit was due to Mr. Mallet for the science and the practical skill combined in the production of the contrivance under discussion; it was perhaps imperfect in some of the details, but he was inclined to believe that, in certain situations, and for vessels of moderate size, it might be adopted. Its construction would certainly be more expensive than that of a patent slip, but it would be less costly than a graving dock, and not liable to injury from hydrostatic pressure, to guard against which frequently constituted a main portion of the expense of a graving dock. The foundation of this structure might be simple, as the weight was distributed over so many points; he conceived, however, that unless it was established where the rise of tide was considerable, the foundation must be laid at a depth of 5 or 6 feet under low-water mark, to allow for the thickness of the frames and the platform beneath the ship's bottom. He was of opinion that a modification of the plan might be advantageously employed for canal lifts.

Mr. Hawkins agreed with Mr. Mallet that a ship must be strained while on a patent slip, because the timbers were all bearing a weight at an angle; but more particularly when leaving the slip, as the stern floated whilst the stem was still on the cradle of the slip.

Mr. Palmer did not admit the advantages of the proposed plan over graving docks, for, as they are now constructed, they possess every requisite convenience for examining the repairing vessels; the gates are made to exclude the water perfectly, and the machinery for pumping is so effective, that a very short time suffices to lay the dock dry. The plan might possess some advantage over Morton's slip in retaining the vessel in a vertical position, but it would be more expensive to construct, and he was not at all convinced that the objections urged against the patent slip were well founded.

Mr. Gordon observed that the position of a ship upon a patent slip was exactly that in which it was built; he could not therefore understand why it should be so very injurious; besides, if the stern cradles were elevated, as was the case on some of the slips proposed by Captain Brown, the vessel remained nearly on an even keel. Another improvement introduced by Captain Brown was, substituting solid rollers for the wheels of Morton's slip, the axles of which frequently twisted and prevented the progress of the vessel. Among the modes of examining the bottoms of vessels enumerated by Mr. Mallet, he had omitted the "gridiron," which consisted of a strong frame of horizontal timbers resting upon the heads of piles a little above low-water mark; over this frame the vessel was moored, and on the tide receding was shored up, resting upon chocks. When it was dry the bottom could be examined, and any slight repair made before the returning tide floated the ship off. "Gridirons" existed at Liverpool, at Havre, and at many other ports.

The President observed, that, like the form of breakwaters, much depended upon locality. Where timber was cheap, and the rise of tide considerable, the plan might be applicable; at Liverpool, where the tide rose 30 feet, and in the Channel Islands, where the rise was 40 feet, the platform might be 10 feet above low-water mark, and still accommodate any ordinary vessel. It certainly appeared to avoid some of the main expences of the graving dock, in which so many precautions must be taken for preventing the springs rising and blowing up the bottom. The Institution was much indebted to Mr. Mallet for the great pains he had bestowed on the communication, for the complete drawings and model illustrating it (which were presented to the Institution,) and he deserved credit for the ingenuity displayed in the contrivance.

*May* 3.

"*Description of the Tunnels, situated between Bristol and Bath, on the Great Western Railway, with the methods adopted for executing the works.*" By Charles Nixon, Assoc. Inst, C. E.

The works described in this paper comprised a large quantity of heavy earth-work in tunnels, etc.; they were commenced in the

spring of the year 1836, and terminated in the year 1840. The whole of the tunnels are 30 feet in height from the line of rails, and 30 ft. in width; they are curved to a radius about 120 chains; the gradient of that part of the line is 4 ft. per mile. The strata through which they were driven consisted generally of hard gray sandstone and shale, with the gray and dun shiver, etc; in a few places only, the new red sandstone and red marl were traversed. Every precaution was taken for securing the roofs, by lining them with masonry where the nature of the strata demanded it, and in some places invert arches were turned beneath. Driftways were driven before the tunnels were commenced, and shafts were sunk to enable the work to proceed at several points simultaneously. The modes of conducting the works by these means are fully described, with all the difficulties that were encountered. The construction of the centres is given, with the manner of linning the arches with masonry, which is stated to be what was termed "coursed rubble;" but was of a very superior description, and in every respect similar to ashlar-work. The author offers some remarks with regard to the expense of working tunnels by means of centre driftways. He states this plan to be costly, and in many instances without corresponding advantages, on account of the difficulty of keeping the road clear for the wagons. He recommends that when driftways are used, they should be on the lower side of the dip of the strata, as the excavation would be facilitated, and the road would be kept clearer. In long tunnels he has found the cheapest and most expeditious mode of working to be by excavating the centre part from shafts, and both the ends (together if possible) from the extremities after the open cuttings are made. The drawing accompanying the paper gave a longitudinal section of all the tuunels, and showed to an enlarged scale several transverse sections of them, where the variations of the strata rendered either partial or entire lining necessary.

*Remarks.*—In answer to questions from Mr. Vignoles and other members, Mr. Nixon explained that the extra number of shafts had been required in order to enable the works to be completed within a given time; there had not been any accidents during his superintendence, but subsequently one of the shafts had collapsed. The cost of driving the driftways, the dimentions of which were 7 feet wide by 8 feet high, was ten guineas per yard lineal. He then described more fully his proposed plan of cutting the driftways on the lower side, instead of the centre of the tunnel, and stated the advantages chiefly to consist of a saving in labor and gunpowder, as a small charge sufficient to lift a considerable mass of rock when acting from the dip; the road was also less liable to be closed by the materials falling into it when the enlarged excavation proceeded from one side instead of upon both sides.

Dr. Buckland, after returning thanks for his election as an honorary member of the Institution, expressed his gratification at the prospect of a more intimate union between engineering and geology which could not fail to be mutually beneficial, and cited examples of this useful co-operation in the cases of railway sections, and mod-

els that had recently been furnished by engineers to the Museum of Economic Geology. He then proceeded to remark upon the geological features of the South-Western Coal Field near Bristol and Bath, which had been described by Mr. Conybeare and himself, in the Transactions of the Geological Society of London (1824.) Some of the tunnels near Bristol are driven in the Pennant Grit of the coal formation. Where it is thrown up at a considerable angle and composed of strata yielding slabs and blocks of hard sandstone used extensively for pavement. In traversing such inclined and dislocated strata, the engineer's attention should, he conceived, be especially directed to the original joints that intersect the beds nearly at right angles to their planes of stratification, and also to the fractures produced during the movements they have undergone. These natural divisions and partings render such inclined stratified rocks unworthy of confidence in the roof of any large tunnel, and liable to have masses suddenly detached. Inclined strata of a similar sandstone are perforated by many tunnels on the railway near Liege, in nearly all of which the roofs are supported by brick arches. It has been found impossible to make the tunnels through Lias and Red Marl without continuous arches of masonry. In any of the tunnels which have been carried through strata of the great oolite, the parts left unsupported by masonry would, in his opinion, be peculiarly liable to danger, because even the most compact beds of oolite are intersected at irregular intervals by loose joints at right angles to the planes of the strata, and occasionally by open cracks; and it is to be feared that the vibration caused by the railway carriages would tend eventually to loosen and detach these masses of stone. He apprehended still greater danger would exist in tunnels cut through the loosely jointed strata of chalk, unless they are lined throughout with strong masonry; and even that, in a recent case, had been burst through by the weight of the incumbent loose chalk coming suddenly upon the arch. In open cuttings through chalk, where the numerous interstices and the absence of alternating clay beds prevent any accumulation of water, there is little chance of such frequent landslips as occur where beds of stone, gravel, or sand rest on beds of clay; but until the side walls of chalk are reduced to a slope at which grass will grow, they will be subject to continual crumblings and the falling down of small fragments, severed by the continual expansion and contraction of the chalk, under the destructive force of atmospheric agents, and chiefly of frost. In open cuttings, where the inclination of the strata is towards the line of rails, the slope should be made at a greater angle than if the strata inclined from the rails; if this be done, fewer landslips will occur from accumulations of water between the strata thus inclined towards the rails; and such slips may be further guarded against by minute and careful observation of the nature of the individual strata and a scientific application of subterranean drains at the contact of each permeable stratum with a subjacent bed of clay. Tunnels can be safely formed without masonry in unstratified rocks of hard granite, porphyry, trap, etc., and in compact slate rocks; also in masses

of tufa, such as cover Herculaneum, and are pierced by the grotto of Pansilippo near Naples; but in his opinion, wide tunnels driven in stratified rock could not be considered secure unless they were supported by arches.

Mr. Sopwith confirmed the remarks on the importance to the civil engineer of a knowledge of the geological character of the strata through which tunnels or open cuttings were to be made; the cost was materially affected, as well as the stability of the works. The angle of inclination and the lines of cleavage should be carefully studied; on one side of a cutting the slope might be left steep, and all would be firm and dry; whilst on the other, if the same slope was adopted, all would appear disintegrated and wet, and a series of accidents would be the necessary consequence. He could not sufficiently urge the importance of a more intimate connexion between the geologist and the engineer.

In answer to a remark by Mr. Farey on the apparent advantages of Frazer's centres for tunnelling, Mr. Bull promised to procure for the Institution an account of the execution of some work with them.

"*Account of the Machinery and Apparatus for compressing and using Gas for Artificial Illumination at the Portable Gas Works of London, Edinburgh, Manchester, and Paris.*" By Charles Denroche Grad. Inst. C. E.

This paper gives an account of the improvements introduced by Mr. David Gordon into the syphon forcing-pumps, reservoirs, etc., whereby the requisite degree of compression was obtained for rendering gas portable for the purposes of illumination, and of the arrangements adopted in the works at Edinburgh, Manchester, London, and Paris. A description is given of the various kinds of apparatus which were tried before a pressure could be obtained of 30 atmospheres, or 450 lb. per square inch. The portable lamps, with their ingeniously contrived graduated cocks are also described with the several parts composing the apparatus. It appears that, owing to the cost of compression, which was 3*s*. 6*d*. per thousand cubic feet, and that of delivery, which amounted to 10*s*. per thousand cubic feet, the speculation was unsuccessful in a mercantile point of view, although most of the mechanical difficulties were overcome. The paper was accompanied by a series of detailed drawings of every part of the apparatus.

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In a paper lately read on some remarkable circumstances connected with the *Daguerreotype*, it was stated that a cameo having been suspended so as to hang near, but not to touch, a polished plate in a box from which all light was excluded, the engraving of the cameo was clearly and distinctly marked on the plate. M. Breguet, the celebrated watchmaker, has addressed a letter to the Academy, in which he states that he has frequently seen, on the polished inner surface of the gold cases of his flat watches, the name of his house plainly and legibly marked, the impression having been received from the engraved letters of the covering of the works, which did not touch the case.